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Background

Flooding varies according to the diversity of landscape features, climate, and human manipulation of the landscape. Flooding occurs in all regions of California at different times of the year and in different forms—examples range from tsunamis in coastal areas to alluvial fan flooding at the base of hillsides, and from fast-moving flash floods to slow-rise deep flooding in valleys. Flood risk and warning times also vary across the state, in general increasing with storm frequency, as well as with floodplain development. Although, a smaller flood that causes less damage might occur more frequently than a very severe flood with much greater consequences. Flood warning times change based on the type of flooding that occurs. For example, slow-rise flooding has a longer lead time, while flash flooding occurs with little to no lead time. Figure 28-1 shows the flooding types in California, as well as the areas of the state where each type is apt to occur.

PLACEHOLDER Figure 28-1 Flood Types in California

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of this chapter.]

When floods occur where people live and work, they can result in tragic loss of life and can have devastating economic impacts by damaging critical infrastructure and vital public facilities, taking valuable agricultural land out of production, and endangering California's water supply system. However, periodic flooding is also a natural phenomenon that helps shape, form, and nurture riverine and coastal floodplain ecosystems. Periodic flooding can mold streambanks, keep erosion and sedimentation in equilibrium, replenish soils, recharge groundwater, filter impurities, and support a variety of habitats for some of California's most sensitive species.

PLACEHOLDER Box 28-1 Flooding Defined

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of this chapter.]

Flood management consists of three primary activities:

- Managing flood risk — keeping floodwater away from people and property
- Managing floodplain resources — keeping people and assets out of the path of floodwater
- Managing floodplain functions — sustaining the natural function of floodplains including creating habitats, attenuating flows, and sediment transport

In the 1800s, flood management was the responsibility of individual landowners (Kelley, 1989). Catastrophic floods in the late 1800s and early 1900s changed attitudes, resulting in a series of flood control statutes that increased Federal and State agency's responsibility for flood management. This resulted in the control of floodwater using structures, such as dams, levees, and floodwalls. These structural solutions often resulted in unintended environmental degradation.

In the 1960s, studies found that damage due to floods was increasing and that continued development in floodplains was increasing residual flood risk. (**Residual risk** is the likelihood of damage or other adverse consequence remaining after flood management actions are taken.) As a result, local, State, and Federal agencies began developing policies and programs that managed floodplains in addition to implementing structural solutions for controlling floodwater (FEMA, 2010). Floodplains by definition include lands adjacent to and behind levees.

Traditional approaches to flood management included developing single-purpose flood infrastructure projects. While this infrastructure reduced the chance of flooding and avoided damage to lives and property, it altered and confined natural watercourses. These alterations lead to unintended consequences, such as loss of ecological function and redirection of flood risks upstream or downstream of projects. Traditional approaches have encouraged urban and agricultural development within floodplains, which has placed people and property at risk of flooding, as well as degraded habitat.

Coordinating flood management planning and operations is a challenge due to the many agencies, jurisdictions, and governance structures involved. Many agencies are responsible for operating and maintaining the extensive system of flood infrastructure, which includes (DWR, 2012):

- More than 11,000 miles of levees
- More than 1,700 dams
- More than 600 debris basins
- 36 major reservoirs
- Many other facilities, including pump stations, monitoring facilities, bypasses, and weirs

While there is a complex system of flood infrastructure across the state, it does not yet provide a basic "100-year" level of protection in all areas of the state. (A "100-Year Flood" is a short hand expression for a flood that has a 1-in-100 probability of occurring in any given year. This can also be expressed as "1 percent annual chance flood". A "500-Year Flood" is a more severe event that has a 1-in-500 (or 0.2 percent) probability of occurring in any given year.)

The *California's Flood Future Report*, a companion plan to the *California Water Plan* (CWP), characterized the potential for flood exposure in California. More than 7 million people and $580 billion in assets (crops, buildings, and public infrastructure) are currently exposed in the 500-year floodplains in California (DWR, 2012). (**Exposure** is a description of who or what is in harm's way.) This includes:

- More than 3.3 million people in the South Coast Hydrologic Region and more than 1 million people in the San Francisco Bay Hydrologic Region who are exposed to flooding
- More than $430 billion in structures that are exposed, including essential, high-potential loss, and lifeline facilities in the South Coast, San Francisco Bay, and Sacramento River hydrologic regions
- More than $5.9 billion in agricultural crops that are exposed to flooding in the Sacramento, Central Valley, and Tulare Lake hydrologic regions
- More than 66,800 acres of tribal land that is within the 500-year floodplains
- [Bullet on environmental resources — to be developed]

The 500-year flood event was used for two reasons-(1) exposure information was calculated based on existing information, which includes only the 100-year and 500-year floodplains statewide, (2) it demonstrates the number of Californians who are at risk from catastrophic flooding events (500-year

event). More detailed information and results from the *California's Flood Future Report* can be found at http://www.water.ca.gov/SFMP.

Further development in flood-prone areas, population growth, and climate change will lead to increased people and property at risk of flooding in the future. While flood infrastructure can reduce the intensity and frequency of flooding, it cannot completely eliminate the flood risk (e.g., residual flood risk will still remain).

Integrated Water Management Approach to Flood Management

Today, the concept of flood management has shifted from a single-purpose approach to a holistic one. Integrated water management (IWM) is a collection of policies, practices, and tools applied to water resources planning and management to achieve multiple objectives and enhanced outcomes. IWM reinforces the interrelation of different water management components—such as water supply, flood management, water quality, and environmental stewardship—with the understanding that changes in the management of one component will affect the others. IWM uses a participatory process that applies knowledge from the various water management disciplines, as well as the insights from diverse stakeholders and land management practitioners. It seeks to implement efficient and sustainable solutions for all the beneficial uses of water. The shift to IWM has resulted in societal benefits, such as improved public safety, maximized funding sources, and increased stakeholder and partner support.

There are six basic strategies for incorporating flood management into IWM:

- **Integrate Flood Management and Land Use —** This strategy incorporates flood management into land use planning recognizing that both have the potential to impact flood magnitudes and flood risks. Land use planning can reduce flood risks by limiting development within floodplains.
- **Leverage Natural Watershed Features —** This strategy leverages natural watershed features to reduce the intensity or duration of flooding. Natural watershed features include undeveloped floodplains that can store and slowly release floodwaters; wetlands that can filter runoff and provide groundwater infiltration; healthy forests, meadows, and other open spaces that can reduce peak flows, mudslides, and sediment loads in streams.
- **Adopt a "Best Mix" of Structural and Nonstructural Approaches** — This strategy compares available structural and nonstructural approaches and selects a strategy or a combination of strategies that is most appropriate for management objectives within the context of natural, engineered, environmental, economic, and political systems.
- **Implement Regional Flood Management at a System Scale —** This strategy evaluates opportunities and potential impacts of flood management at a regional scale. IWM incorporates a broad range of stakeholder perspectives, which results in improved planning and coordination. Coordinating across geographic and agency boundaries, achieves sustainable outcomes, informed decisions, and prioritized investments.
- **Promote Multiple Benefits —** This strategy focuses on implementing projects with multiple benefits. For example, managed floodwaters and stormwater could be a resource for water supply augmentation, pollution prevention and source control, as well as ecosystem restoration and recreation.
- **Implement Multiple -Hazard Management —** This strategy incorporates flood risks induced by other hazards, such as landslides, wildfires, and earthquakes, into a multiple hazard

approach to planning. For example, landslides and wildfires can contribute to debris-flow flooding while earthquakes can lead to tsunami flooding or dam or levee failure.

IWM is the future of flood management in California. IWM provides an overall flood management strategy for long-term economic stability, public safety, and enhancement of environmental stewardship. As agencies move toward this integrated approach to flood management, the number of successful IWM projects will increase. Two examples of successful IWM projects are provided in Boxes 28-2 and 28-3.

PLACEHOLDER Box 28-2 Lower Carmel River Floodplain Restoration and Flood Control Project

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of this chapter.]

PLACEHOLDER Box 28-3 Upper San Diego River Improvement Project

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of this chapter.]

Flood Governance — Policies and Institutions in California

Traditional flood management resulted in a complex network of agencies with overlapping responsibilities. These agencies have responsibility for some aspect of flood management, including planning, administering, financing, and maintaining flood management facilities and emergency response programs. Each agency has its own objectives, authorities, roles, responsibilities, and jurisdictions. Agencies include Federal, State, and tribal entities (defined here as federally recognized tribes and tribal communities); as well as, cities, counties, community service areas and districts, drainage and storm drainage districts, flood control districts, irrigation districts, levee protection districts, joint power authorities, public works districts, public utilities districts, reclamation districts, resource conservation districts, sanitation or sewer districts, special districts, water agencies and departments, and water conservation districts. Almost all communities in California have responsibility for floodplain management, including adopting National Flood Insurance Rate Maps, conforming to the International Building Code, and enforcing building restrictions.

Key State agencies with responsibilities related to flood management include:

- Department of Water Resources (DWR) is the primary State agency responsible for flood management planning, construction, emergency management, operation, and maintenance.
- California Emergency Management Agency (CalEMA) is responsible for the State's emergency management, which includes readiness, response, and recovery from all hazards (including flooding). CalEMA is also responsible for assisting local agencies in emergency preparedness, response, recovery, and hazard mitigation planning efforts. In addition, CalEMA administers Federal Emergency Management Agency's (FEMA) flood grant program.
- California Department of Fish and Game works with DWR in managing environmental resources associated with planning, construction, operation, and inspection of flood management facilities.
- The Central Valley Flood Protection Board (CVFPB) is responsible for oversight of the State Plan of Flood Control (SPFC). The SPFC is a portion of the flood protection system in the Central Valley for which the State has provided assurances of cooperation to the Federal

government. The CCVPB also has regulatory authority over projects carried out along or near the Sacramento and San Joaquin rivers and their tributaries.

A number of other State agencies also have responsibilities related to flood management, including:

- State Water Resources Control Board
- Regional Water Quality Boards
- California Coastal Commission
- California Department of Transportation

Key Federal agencies with responsibilities related to flood management include the U.S. Army Corps of Engineers (USACE) and FEMA. USACE has nationwide responsibility for flood management and permitting authority over activities affecting waters of the United States. USACE also:

- Assists in statewide and regional planning efforts
- Partners with the State in project development
- Plans, designs, and constructs facilities to reduce flood damages
- Funds the Federal share of costs of project development
- Permits modifications to Federally authorized flood management facilities
- Regulates projects with regard to portions of the Rivers and Harbors Act and the Clean Water Act
- Manages and funds floodfight and rehabilitation assistance through Public Law 84-99

FEMA, an agency of the U.S. Department of Homeland Security, is responsible for emergency management and floodplain management. FEMA coordinates the Federal response to floods, earthquakes, hurricanes, and other natural or man-made disasters and provides disaster assistance to states, communities, and individuals. Floodplain management is administered through the National Flood Insurance Program (NFIP), which has three major components- flood insurance, floodplain mapping, and floodplain management. Other federal agencies with responsibilities or directives related to flood management include U.S. Bureau of Reclamation, Natural Resources Conservation Service, the National Park Service, the National Weather Service, U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), and U.S. Fish and Wildlife Service.

A number of State laws were enacted in 2007 regarding flood risk and land use planning. These laws establish a comprehensive approach to improving flood management by addressing system deficiencies, improving flood risk information, and encouraging links between land use planning and flood management. Many of the requirements established by these laws are applicable only within the Central Valley.

A summary of the legislation is provided below.

- **Senate Bill (SB) 5 (2008) Flood Management —** requires DWR and the CVFPB to prepare and adopt a Central Valley Flood Protection Plan (CVFPP) by 2012. The bill also requires cities and counties within the valley to amend General Plans and zoning ordinances within a specified timeframe following adoption of the CVFPP. By 2015, these cities or counties are prohibited from entering into a development agreement, approving any permit, entitlement, or subdivision map unless an urban level of flood protection is provided. ("Urban level of flood protection" is defined as the level of protection necessary to withstand flooding that has a 1-in-200 chance of occurring in any given year.)

- **AB 156 (2007) Flood Control —** provides DWR and the CVFPB with specific authorizations that would enhance information regarding the status of flood protection in the Central Valley. The bill specifically directs DWR to map areas at risk of flooding, prepare a status report on the Central Valley SPFC, identify flood zones protected by levees, and supply notification about flood risk and flood insurance to property owners in those levee-protected flood zones. The bill also requires DWR to specify system deficiencies and planned rehabilitation, including a cost estimate. Components of this bill apply statewide.
- **AB 70 (2007) Flood Liability —** provides that a city or county may be responsible for its reasonable share of property damage caused by a flood, if the State liability for property damage has increased due to approval of new development after January 1, 2008.
- **AB 162 (2007) General Plans —** requires annual review of the land use element of general plans for areas subject to flooding, as identified by FEMA or DWR floodplain mapping. The bill also requires the housing element to include a conservation element of the general plan, which would identify rivers, creeks, streams, flood corridors, riparian habitat, and land that might accommodate floodwater for purposes of groundwater recharge and stormwater management.

The DWR FloodSAFE initiative created in 2006 consolidated and coordinated DWR's programs for flood management. Two major milestone reports under the FloodSAFE initiative include the CVFPP and the California's *Flood Future: Recommendations for Managing Flood Risk Report* (*California's Flood Future Report*; DWR, 2012). The CVFPP, which was adopted in June 2012, proposes a systemwide investment approach for sustainable, integrated flood management in areas currently protected by facilities of the SPFC. The *California's Flood Future Report* identifies flood management issues statewide and presents recommendations to help address the statewide issues.

Flood Management Actions

Management actions serve as a toolkit of potential actions that local, State, and Federal agencies can use to address flood-related issues and promote IWM. These actions range from policy or institutional changes to operational and physical changes to flood infrastructure. Such actions are not specific recommendations for implementation; rather, they serve as a suite of generic management tools that can be used or combined for specific application situations. Management actions can also be integrated with other resource management objectives (e.g., water supply, water quality, ecosystem restoration, and recreation) to create multiple -benefit projects. An example of a project that has combined many management actions to address a variety of flooding issues is included in Box 28-2. A full suite of management actions was developed as part of the *California's Flood Future Report* and can be found at http://www.water.ca.gov/SFMP. The complete list of management actions has been summarized into 10 broad categories. These categories are described below.

Category A: Flood Infrastructure

Flood infrastructure varies significantly based on the type of flooding. Flood infrastructure can include:

1. **Levees and Floodwalls —** These increase flood-carrying capacity by containing the waters of a stream or lake. Levees are an earthen or rock berm constructed parallel to a stream or shore (or around a lake) to provide protection from all types of flooding. Levees could be placed

close to the stream edge, or farther back (e.g., a setback levee). Ring levees could be constructed around a protected area, isolating the area from potential floodwaters.

2. **Channels and Bypasses** — These convey floodwaters to prevent slow-rise, flash, and debris-flow flooding. Channels can be modified by deepening and excavating the channel to increase its capacity, or lining the streambed and/or banks to increase drainage efficiency. Channel modifications can result in increased erosion downstream, degradation of adjacent wildlife habitat, and often require extensive permitting. Bypasses are structural features that divert a portion of flood flows into adjacent lands (or underground culverts) to provide additional flow-through capacity and/or to store the flows temporarily and slowly release and infiltrate the stored water.
3. **Coastal Armoring Structures and Shoreline Stabilization —** These protect low-lying coastal areas from flooding. Coastal armoring structures are typically massive concrete or earthen structures that keep elevated water levels from flooding interior lowlands and prevent soil from sliding seaward. The cost of armoring is justified when flooding and wave damage threatens substantial human investment. Shoreline stabilization reduces the amount of wave energy reaching a shore or restricts the loss of beach material to reduce shoreline erosion rates. Types of shoreline stabilization include breakwaters, groins, and natural and artificial reefs.
4. **Debris Mitigation Structures —** For debris and alluvial flooding, Sabo dams, debris fences, and debris basins separate large debris material from debris flows, or they contains debris flows above a protected area. These structures require regular maintenance to periodically remove and dispose of debris after a flood. Deflection berms (or training berms) can be used to deflect a debris flow or debris flood away from a development area and allow debris to deposit in an area where it would cause minimal damage.

Category B: Reservoir and Floodplain Storage and Operations

Reservoir and floodplain storage and operations consist of:

1. **Reservoir and Floodplain Storage —** This provides an opportunity to regulate flood flows by reducing the magnitude of flood peaks occurring downstream. Reservoirs collect and store water behind a dam and release it after the storm event. Most California reservoirs with significant storage capacity are multiple purpose projects providing water supply, and flood management, as well as environmental, water quality, and recreation benefits. Floodplain storage occurs when peak flows in a river are diverted to adjacent off-stream areas. Floodplain storage can occur naturally when floods overtop a bank and flow into adjacent lands, or the storage can be engineered using weirs, berms, or bypasses to direct flows onto adjacent lands.
2. **Storage Operations —** This can potentially be improved to reduce downstream flooding by optimizing the magnitude or timing of reservoir releases, or through greater coordination of storage operations. Coordination can take the form of formal agreements among separate jurisdictions to revise reservoir release operations based on advanced weather and hydrology forecasts, or it can simply involve participation in coordination meetings during flood emergencies.

Category C: Operations and Maintenance

Operations and maintenance is a crucial component of flood management. Operations and maintenance activities can include inspection, vegetation management, sediment removal, management of encroachments and penetrations, repair or rehabilitation of structures, or erosion repairs. Because many flood facilities constructed in the early to mid-twentieth century are near or have exceeded the end of their expected service lives, adequate maintenance is critical for these flood facilities to continue functioning properly.

Category D: Land Use Planning

Land use planning employs policies and practices to limit development in flood-prone areas and encourages land uses that are compatible with floodplain function. These policies might include floodplain regulations and stream protection ordinances that restrict or prohibit development within floodplains. Stormwater management practices, open space preservation, and watershed management programs help reduce the extent of impervious surfaces, and preserve the ability of bodies of water and open spaces to absorb precipitation and slowly release runoff. Policies might include measures to impose conditions on future construction that would restrict the size and placement of structures, would encourage reduction of impervious areas, and would encourage the long-term restoration of streams and floodplains. Where development is permitted, measures might require protection of buildings from potential flood damage (such as floodproofing, described below) or measures to reduce potential impacts to other development, such as requiring that new development result in no adverse flood impacts to existing structures.

Category E: Floodplain Management

Floodplain management generally refers to nonstructural actions to floodplains that reduce flood damages and losses. Floodplain management actions include:

1. **Floodplain Mapping and Risk Assessment —** This serves a crucial role in identifying properties that are at a high risk to flood. Local communities, State government, and the private sector require accurate, detailed maps to prepare risk assessments, guide development, prepare plans for community economic growth and infrastructure, utilize the natural and beneficial function of floodplains, and protect private and public investments. The development of needed technical information includes topographic data, hydrology, and hydraulics of streams and rivers, delineation of the areas subject to inundation, assessment of properties at risk, and calculation of the probabilities of various levels of loss from floods.
2. **Land Acquisitions and Easements —** These can be used to restore or preserve natural floodplain lands and to reduce the damages from flooding by preventing urban development. Land acquisition involves acquiring full-fee title ownership of the lands. Easements provide limited-use rights to property owned by others. Flood easements, for example, are purchased from a landowner in exchange for the perpetual right to periodically flood the property when necessary or to prohibit the planting of certain crops that would impede flood flows. Conservation easements can be used to protect agricultural or wildlife habitat lands from urban development. Although acquisition of lands or easements can be expensive, they can reduce the need for structural flood improvements that would otherwise be needed to reduce flood risk.
3. **Building Codes and Floodproofing —** These include specific measures that reduce flood damage and preserve egress routes during high-water events. These codes could require floodproofing measures that increase the resilience of buildings to flooding through structural changes, elevation, or relocation.
4. **Retreat —** Retreat is the permanent relocation, abandonment, or demolition of buildings and other structures to allow the shoreline to advance inward unimpeded. It is used for areas subject to high coastal flooding risks, high erosion rates, or future sea-level rise. In some areas, coastal flood risk is high, shoreline protection efforts and repeated maintenance are costly, and preventing erosion is difficult.

5. **Flood Insurance —** This is provided by the Federal government via the NFIP to communities that adopt and enforce an approved floodplain management ordinance to reduce future flood risk. The NFIP enables property owners in participating communities to purchase insurance as a protection against flood losses.
6. **Flood Risk Awareness — Information and Education** — This is a critical component of IWM because it encourages prudent floodplain management. To understand potential risks, flood hazard information is a prerequisite to sound education. If the public understands the potential risks, they can make decisions to reduce their risk, increase their personal safety, and expedite recovery after floods. Effective risk awareness programs are critical to building support for funding initiatives and to building a connection to the watershed.

Category F: Natural Floodplain and Ecosystem Functions

Actions that support natural floodplain and ecosystem functions include:

1. **Natural Hydrologic, Geomorphic, and Ecological Processes** — These processes are a key component of promoting natural floodplain and ecosystem functions**.** Human activities (including infrastructure, such as dams, levees, channel stabilization, and bank protection) have modified natural hydrological processes by changing the extent, frequency, and duration of natural floodplain inundation. This has disrupted natural geomorphic processes, such as sediment erosion, transport, and deposition, which normally cause channels to migrate, be cut off, and split and rejoin downstream. These natural geomorphic processes are important drivers in creating a diversity of riverine, riparian, and floodplain habitat to support fish and wildlife. Restoration of these processes might be achieved through setting back levees, restoring channel alignment, removing unnatural hard points within channels, or purchasing lands or easements that are subject to inundation.
2. **Quantity, Quality, and Connectivity of Native Floodplain Habitats —** This is critical in promoting natural floodplain and ecosystem functions**.** In some areas, native habitat types and their associated floodplain have been lost, fragmented, and degraded. Lack of linear continuity of riverine, riparian habitats, or wildlife corridors, impacts the movement of wildlife species among habitat patches and results in a lack of diversity, population complexity, and viability. This can lead to native fish and wildlife becoming rare, threatened, or endangered. Floodplain habitat creation or enhancement can be accomplished through setting back levees, expanding channels or bypasses, or through removal of infrastructure that prevents flood flows from entering floodplains.
3. **Invasive Species Reduction —** Minimizing invasive species can help address problems for both flood management and ecosystems. Invasive species can reduce the effectiveness of flood management facilities by decreasing channel capacity, increasing rate of sedimentation, and increasing maintenance costs. Non-native, invasive plant species can often out-compete native plants for light, space, and nutrients, further degrading habitat quality for native fish and wildlife. These changes can supersede natural plant cover, eliminate, or reduce the quality of food sources and cover for indigenous animal species, and disrupt the food chain. Reductions in the incidence of invasive species can be achieved by defining and prioritizing invasive species of concern, mapping their occurrence, using best management practices for invasive species control, and using native species for restoration projects.

Category G: Permitting

Numerous permits are required to conduct routine maintenance, restoration, physical improvements, and other activities. Regional and programmatic permitting methods can provide faster and better delivery of flood management projects. Project-by-project environmental permitting can result in time-consuming negotiations to identify suitable offsite mitigation areas as compensation for habitat losses and often lead to small, isolated restoration areas. These negotiations are repeated for each permit renewal, which can lead to new requirements for existing projects. Regional and programmatic permitting methods can be used to collectively meet permitting needs for multiple projects, over longer planning horizons, while also consolidating mitigation and conservation efforts into larger, more viable conservation areas. This could accelerate permitting of flood system projects and direct mitigation to larger projects of greater ecological value. This results in lower per-unit costs versus project-by-project mitigation. Regional and programmatic permitting methods include regional Habitat Conservation Plans, Natural Community Conservation Plans, programmatic Endangered Species Act (ESA) Section 7 consultations, and Regional General Permits. Additional approaches are being developed, including Regional Advance Mitigation Planning and Corridor Management Plans. Regional Advance Mitigation Planning establishes a regional framework for identifying mitigation approaches that support the needs of planned infrastructure projects before they are constructed. Corridor Management Plans are long-term plans that identify and prioritize repairs and/or new construction, long-term routine maintenance, and ecosystem restoration opportunities for a discrete corridor. These plans serve as a foundation for securing programmatic regulatory agency approvals for ongoing maintenance activities and habitat restoration.

Category H: Flood Emergency Management (Flood Preparedness, Response, and Recovery)

Flood emergency management includes the following preparedness, response, and recovery activities:

1. **Flood Preparedness** — Flood preparedness includes the development of plans and procedures on how to respond to a flood in advance of a flood emergency, including preparation of emergency response plans, training of local response personnel, designation of evacuation procedures, conducting exercises to assess readiness, and developing emergency response agreements that address issues of liability and responsibility.
2. **Emergency Response —** Emergency response is the aggregate of all those actions taken by responsible parties at the time of a flood emergency. Early warning of flood events through flood forecasting allows the timely notification of responsible authorities so that plans for evacuation of people and property can be implemented. Emergency response also includes floodfighting and emergency sheltering.
3. **Post-Flood Recovery** — Recovery programs and actions include restoring utility services and public facilities, repairing flood facilities, draining flooded areas, removing debris, and assisting individuals, businesses, and communities to protect lives and property. Recovery planning can include development of long-term floodplain reconstruction strategies to determine whether reconstruction will be allowed in flood-prone areas. Such planning should review what building standards should be required, how the permit process for planned reconstruction can be improved, and how natural floodplains and ecosystem functions can be incorporated.

Category I: Policy and Regulations

Several management actions can improve agency coordination and lead to more consistent policies and regulations. Clarifying flood management roles and responsibilities for local, regional, State, and Federal agencies can help improve coordination across the large number of agencies and entities involved in flood management. Multiple jurisdictional and regional partnerships can also be encouraged for flood planning and flood management activities, including operation and maintenance, repair, and restoration. Coordination between agencies and responsible parties can take many forms, including roundtable discussions, oversight committees, interagency liaisons, re-purposed agencies, joint power authorities, councils of governments, or new entities.

Category J: Finance and Revenue

Several finance and revenue strategies can increase the ability to fund flood management projects. Aligning flood management projects with other existing or planned projects (such as roads or highways) leverages funding from different agencies and jurisdictions to help accomplish objectives. Consolidating projects on a regional or systemwide level can also improve cost-effectiveness and financial feasibility by pooling resources. Another strategy that can help support economic justification of multiple purpose projects is establishing methodologies to determine the value of benefits that do not have an obvious monetary value, such as ecosystem restoration or systemwide benefits. Collecting fees from areas that share in systemwide benefits, even if the areas do not directly receive flood protection, represents an opportunity to more equitably finance flood management improvements. Guidelines also can be developed to set regional and system/statewide priorities.

Connections to Other Resource Management Strategies

While all of the resource management strategies in the Water Plan Update 2013 share a connection with IWM, several are more closely linked to flood management. Some resource management strategies share positive two-way synergies with flood management including: land use planning and management, sediment management, watershed management, urban runoff management, agricultural lands stewardship, and forest management. Other resource management strategies are tools, which can directly contribute to flood management, such as conveyance, surface storage, system reoperation, and outreach and education. Still other resource management strategies directly benefit from the useful functions of flooding or flood management activities. These resource management strategies include ecosystem restoration, pollution prevention, water-dependent recreation, recharge area protection, conjunctive management, and groundwater storage. More information on each of these resource management strategies can be found in their respective chapter under the Resource Management Strategies section of the CWP Update 2013.

The resource management strategies that share synergies with flood management are described in detail below:

- **Land Use Planning and Management**: The way in which land is used—the type of land use, transportation, and level of use—has a direct relationship to flood management. One of the most effective ways to reduce the vulnerability to potential flooding is through land use planning that is fully abreast and reflective of applicable flood information and flood management practices. By focusing compact development in established urban areas and avoiding more development in floodplains, the need for expensive flood facilities can be

minimized and flood risk can be reduced, protecting critical infrastructure and easing the burden on flood managers.

- **Sediment Management:** Floods have a major role in transporting and depositing unconsolidated sediment onto floodplains. Erosion and deposition help in determining the shape of the floodplain, the depth and composition of soils, and the type and density of vegetation. Disruption of natural sediment transport dynamics can cause failure of adjacent levees through increased erosion or can reduce the flood-carrying capacity of natural channels through increased sedimentation. Sediment is also a major component of alluvial fan and debris-flow flooding.
- **Watershed Management**: Watersheds are an appropriate organizing unit for managing floodplains. Restoring, sustaining, and enhancing watershed functions are a key goal of flood management in the context of IWM.
- **Urban Runoff Management:** Urbanization creates impervious surfaces that reduce infiltration of stormwater and can alter flow pathways and the timing and extent of flooding. The impervious surfaces increase runoff volumes and velocities, resulting in streambank erosion, and potential flooding problems downstream. However, watershed approaches to urban runoff management attempt to capture, treat, and use urban runoff for beneficial uses in a manner that mimics the natural hydrologic cycle. Urban runoff is strongly linked to stormwater, however, stormwater generally is lower in volume and impacts a smaller area compared to flood flows.
- **Agricultural Lands Stewardship:** Due to the flat topography and rich soils caused by historical flood deposits, floodplains are often ideal for agricultural uses. Agricultural conservation easements keep land in private ownership and management, prevent urban development within floodplains, and alter farming and ranching practices to those compatible with floodplain management.
- **Forest Management**: Forestation practices can influence sediment transport from upland streams as well as the timing and magnitude of peak flows. The high surface roughness of forested floodplains reduces floodwater velocities, spreads flows across a larger area of the floodplain, and attenuates downstream lows. Wildfires can increase peak flows and reduce surface water infiltration, which can cause erosion and debris flooding.

Resource management strategies which are tools that directly contribute to flood management include:

- **Conveyance:** Many streams and channels are used to support both flood flow conveyance and water supply conveyance. Improvements to regional water supply conveyance systems could enhance the potential for flood flow conveyance, and vice versa.
- **Surface Storage:** Most of California's major surface water reservoirs are managed for multiple purposes, including flood management, water supply, hydropower, water quality, recreation, and ecosystem needs. Increasing local and regional surface storage has the potential to provide greater water management flexibility for capturing runoff and controlling flood flows.
- **System Reoperation:** The primary goal of forecast-coordinated and forecast-based operations is to improve downstream flood protection without affecting water supply and environmental or recreational uses, through better hydrologic forecasting and coordinated reservoir operations.
- **Outreach and Education:** Outreach is needed to regularly educate the public on flooding, flood risks, floodproofing, and impacts of climate change, as well as to explain what households, businesses, and communities can do to reduce or mitigate risk to acceptable levels. Outreach is also needed to educate the public on the natural, beneficial functions of floodplains.

Resource management strategies that benefit directly from the useful function of flooding include:

- **Ecosystem Restoration:** Floodplain environments are dynamic in nature and are highly productive biological communities given their proximity to water and the presence of fertile soils and nutrients. Native riparian and aquatic animal and plant communities of California are adapted to conditions of seasonal flooding. The principal opportunities for improvement in both flood and ecosystem restoration occupy the same spatial footprint and are affected by the same physical processes that distribute water and sediment in rivers and across floodplains. Integrating ecosystem conservation and restoration into projects for flood risk reduction is an essential component of sustainable flood management. Flood management projects that protect and restore ecosystems will likely create increased effectiveness, sustainability, and public support.
- **Pollution Prevention:** Well functioning floodplains improve water quality by filtering impurities and nutrients, processing organic wastes, controlling erosion and sedimentation of streams, and moderating temperature fluctuations.
- **Water-Dependent Recreation:** Floodplains are often ideal locations for parks and numerous other outdoor activities, such as water-oriented sports, boating, swimming, hiking, and camping. Flood protection facilities can improve recreational access to waterways by providing opportunities for integrating suitable recreation facilities.
- **Recharge Area Protection, Conjunctive Management, and Groundwater Storage:** Diversions of flood flows for groundwater infiltration can reduce downstream flooding and improve water supply. The generally flat topography of natural floodplains and the permeable nature of alluvial soils promote infiltration into the subsurface for storage in soils and aquifers.

Potential Benefits of IWM Approach to Flood Management

An IWM approach to flood management provides several advantages that improve the delivery and implementation of flood management projects. These benefits include flood damage reduction; as well as opportunities for water supply and groundwater recharge, water quality, ecosystem restoration, hydropower, and navigation. Societal benefits associated with construction of flood infrastructure include economic sustainability resulting from improved public safety, recreational opportunities, and enhanced environmental functions. When IWM is included in project design, associated IWM benefits can improve traditional benefit-cost ratios and access to project funding. An example of a project that has provided multiple benefits is included in Box 28-3. Table 28-1 provides a summary of flood risk reduction benefits, potential benefits to other major IWM components (e.g., water supply, ecosystem restoration, recycling, water quality, hydropower, and navigation), and costs for each management action. Benefits of an IWM approach to flood management are described below for each major management action category.

Category A: Flood Infrastructure

Flood infrastructure reduces the susceptibility of people and property to harm (vulnerability). Levee setbacks, channels, and bypasses provide opportunities for groundwater recharge, ecosystem restoration, and recreation. The reconnection of streams to their historical floodplains allows the restoration of native floodplain vegetation and provides an expansive area where floodwaters can slow in velocity and disperse over a broader area before infiltrating into the ground. Levee setbacks, channels, and bypasses can increase recreation access to waterways and can be integrated with suitable recreation facilities, such as trails, picnic sites, and wildlife viewing areas. Establishing greenways as part of flood management

projects and replacing concrete channels with more natural creek environments can satisfy recreation demand in urban areas. Several channels and bypasses in California that are subject to flooding also provide navigation benefits when used for interstate commerce or water supply benefits. Debris mitigation structures improve water quality by reducing the amount of sediment from debris flooding. Natural and artificial reefs can provide coastal habitat for corals, sponges, and other reef-building organisms and/or provide recreational surfing benefits when designed for this purpose.

Category B: Reservoir and Floodplain Storage and Operations

Floodplain and reservoir storage and operations reduce food risk by influencing the probability, extent, or depth of flooding (flood hazard). Floodplains provide a natural buffer from flood events by attenuating peak flows. Floodplain storage can provide opportunities for groundwater recharge, ecosystem restoration, and recreation by reconnecting streams to their historical floodplains and integrating suitable recreation facilities. Floodplains provide a natural buffer from flood events by attenuating peak flows. Reservoir storage and storage operations can also result in multiple benefits. Multiple purpose reservoirs store and collect floodwaters that are later used for water supply. Although reservoirs interrupt natural flow patterns and impede fish passage, they can deliver benefits to fisheries by providing cold water for regulating stream temperatures. Many multiple -purpose reservoirs support recreational activities, such as boating and swimming. California's major surface water reservoirs that are managed for flood management also generate hydropower or are hydraulically connected to reservoirs that generate hydropower. Optimizing storage operations provides more water management flexibility to achieve multiple benefits.

Category C: Operations and Maintenance

Operations and maintenance (O&M) reduces the susceptibility of people and property to harm from flooding (vulnerability). O&M activities can be conducted in ways that provide benefits to ecosystem restoration. For example, erosion repair and bank stabilization can be made more environmentally friendly by reexamining current geomorphic processes, using natural materials where practical, and including sloping riparian benches with vegetation for bank stabilization and riparian habitat. Channel dredging operations to increase channel capacity can provide navigation benefits. O&M helps maintain existing flood infrastructure and past investments to protect public safety.

Category D: Land Use Planning

Land use planning reduces flood risk by affecting who and what might be harmed by flooding (exposure) and can be used to protect natural systems while promoting compact and sustainable development. Land use planning reduces water demand through water recycling, capturing and reusing stormwater, recharging and protecting groundwater, protecting ground- and surface water from failed septic systems, and encouraging growth in areas with sufficient water supplies. Appropriate planning can reduce runoff volumes and improve the quality of runoff water. Ecosystem restoration benefits can be achieved by planning development in noncritical habitat areas and preserving natural floodplains. Recreation benefits can also be provided by supporting recreational activities in floodplains and flood greenways.

Category E: Floodplain Management

One of every five Californian's lives in the 500-year floodplain; therefore, the benefits of floodplain management are important and have far-reaching impacts. Floodplain management is focused on addressing flood risk by understanding who and what is at risk, land acquisition and easements, improving building codes and floodproofing efforts, providing flood insurance, and improving flood awareness. Risk assessments and mapping of floodplains provide the tools for proper planning, resulting in improved public safety, environmental stewardship, and economic stability. The benefits of land acquisitions and easements include opportunities for groundwater recharge, wildlife habitat protection, restricting development within the floodplain, preserve land for recreational purposes, and providing water quality benefits. Other benefits include restoration of natural system functions that help support ecosystems, attenuate flows, and provide recreational opportunities. Building codes and flood insurance provide public safety and property protection. These also promote flood awareness by informing residents about the potential impacts of flooding in their geographic area. Coastal retreat can also increase opportunities for coastal ecosystem restoration or recreation benefits.

Category F: Natural Floodplains and Ecosystem Functions

Encouraging natural hydrologic, geomorphic, and ecological processes reduces food risk by influencing the cause of the harm, including the probability, extent, or depth of flooding (flood hazard). The restoration of ecosystem functions can encourage natural groundwater recharge, and improve water quality through filtering runoff, controlling erosion and sedimentation, and moderating temperature fluctuations. Ecosystem restoration can provide areas of active and passive-use recreation, increase open space, and provide scenic value, which results in economic and societal benefits.

Category G: Permitting

Regional and programmatic permitting can cover a large variety of management actions, including operations and maintenance, flood infrastructure, restoration of historical channel alignment, control of invasive species, management of runoff through watershed management, and floodplain management activities. The permitting process can help achieve ecosystem restoration benefits through environmental mitigation. By facilitating the implementation of other management actions, permitting can help achieve water supply, ecosystem restoration, recreation, and water quality benefits.

Category H: Flood Emergency Management (Flood Preparedness, Response, and Recovery)

Flood emergency management includes flood preparedness, response and recovery. Flood preparedness and emergency response address flood risk by reducing the susceptibility of people and property from flooding and reducing residual risk. Flood recovery improves public safety in the aftermath of a disaster and promotes economic growth. Flood preparedness and emergency response address flood risk by reducing the susceptibility of people and property from flooding and reducing residual risk. Flood recovery improves public safety in the aftermath of a disaster and promotes economic growth.

Category I: Policy and Regulations

Policy and regulations improve coordination among agencies involved in flood management. Policies and regulations indirectly result in flood risk reduction, ecosystem restoration, water supply recreation, water quality, navigation, or hydropower benefits. However, potential benefits of policy and regulatory actions that improve coordination include streamlined permitting and approval processes; more efficient and cost-effective routine maintenance and repairs; more successful and sustainable environmental mitigation and conservation; better leveraging of available funding sources; and prioritized multiple benefit flood management projects.

Category J: Finance and Revenue

Finance and revenue management actions improve the ability to finance flood management projects and programs, but indirectly provide flood risk reduction, water supply, ecosystem restoration, recreation, navigation, or hydropower benefits. Guidelines can be set that enable projects to be prioritized on a regional or system/statewide level so that limited funding can be used efficiently.

Other Advantages of an IWM Approach to Flood Management

There are several other advantages of an IWM approach to flood management that improve the delivery and implementation of flood management. Improved agency interaction is at the core of implementing these advantages because a diverse set of stakeholders must coordinate, cooperate, and collaborate to develop successful IWM projects. This interaction helps create opportunities to build advocacy, increase transparency, promote creativity in project design, and accelerate project implementation. Coordination among diverse agencies, including tribal entities, can be effective in addressing jurisdictional and facility ownership issues and restrictions commonly encountered in complex flood and water management projects. Agency interaction also can be used to reach agreement on tools for assessing risk, emergency management, and public awareness as well as regional planning efforts. Improved agency interaction also facilitates effective planning, agency alignment, and identification of investment priorities and funding.

Regional, Systemwide, and Statewide Planning: The benefits of regional, systemwide, and statewide planning results in improved agency interaction and improved project development processes. Evaluating opportunities and potential impacts of flood management from a regional, systemwide, and statewide perspective helps comprehensively manage interactions among water, sediment, and pollutants. This approach can ensure that local institutions do not ignore the effect of their actions on other stakeholders in their watershed and that solutions are developed in coordination with related efforts. This approach to planning provides an opportunity to consolidate ecosystem restoration efforts into larger, more viable conservation areas.

Agency Alignment: Agency alignment results in agencies at all levels (local, state, and Federal agencies as well as tribal entities) having common policy and governance objectives for project development in order to expedite priority projects. The key benefit of agency alignment for flood management is reduced permitting and mitigation process costs as well as improving governance and policy.

- **Reducing Permitting and Mitigation Costs:** Programmatic permitting can reduce overall permitting and mitigation costs. Leveraging natural watershed functions also can help reduce

environmental impacts of flood management projects and protect the environment. Providing habitats for sensitive species expands project benefits and facilitates regulatory approval.

- **Improving Governance and Policy:** Agency alignments can improve agreement between, and within agencies regardless of their governance structure through linking of common goals or objectives. It can address potential areas of conflict in project goals; these can reduce potential conflicts about goals early in the process and reduce unintended consequences.

Agency alignment at all levels (local, state, and Federal agencies as well as tribal entities) enables statewide planning to be competed that identifies governance and policy needs required to develop statewide investment priorities.

Reliable Funding and Investment Priorities: Setting statewide investment priorities encourages development of integrated projects and increases the pool of available funding making it more reliable.

- **Reliable Funding** Local, State, and Federal agencies and tribal entities are beginning to structure their flood management programs to support multiple -benefit projects. These multiple objective projects have access to different or new funding sources. Partnering with other agencies can increase flexibility for pursuing diverse funding sources to overcome grant caps and varied eligibility requirements. Coordination across geographic and agency boundaries can help agencies pool and leverage their funding to make the best use of limited human and financial resources. Agencies working together for multiple -benefit projects can maximize existing funding sources, making them more reliable.
- **Develop Investment Priorities:** Moving toward regional and systemwide planning and IWM coalesces regional and system priorities for evaluation at a statewide level. Having policies, guidelines and governance in place enables the setting of statewide investment priorities that recognize the benefits of integrated projects and processes. Identifying benefits of investment priorities is a move toward more integrated water projects.

Potential Costs of IWM Approach

The costs of implementing flood management are significant. Between $32 and $52 billion for flood management improvements and projects have been identified throughout California by local, State, and Federal agencies, and tribal entities (DWR, 2012). These improvements and projects were identified in the *California's Flood Future Report* and include (DWR, 2012):

- More than 850 local projects totaling approximately $10.5 billion (approximately 20 percent of these projects to not yet have cost estimates)
- Approximately $6 billion of Federal Fiscal Year 2011-2012 Congressional appropriations requested by USACE (These appropriations include feasibility studies as well as design/construction projects.)
- $14 to $17 billion in future investment needs identified in the CVFPP
- A range of potential costs from $0.1 billion to more than $17 billion for improvements on Sacramento-San Joaquin Delta levees that would achieve different levels of flood protection
- More than 28 percent of the local projects identified above qualify as IWM

Unfortunately, however, billions more than this would be needed to provide for basic 100-year flood protection across the state (DWR, 2012).

The costs of different management actions vary significantly. Developing a new reservoir can cost billions of dollars, while some policy and regulatory management actions can be implemented for minimal investments of time and money. In addition to the initial costs for an action, provisions must be made for long-term O&M. Costs for implementing a single management action can also vary widely based on quantity, location, real estate costs, permitting and mitigation costs, and other factors. Therefore, potential costs for flood management actions are summarized qualitatively in Table 28-1. Initial costs and annual costs for each management action were characterized with a low, medium, or high value, which represents the relative cost of the management action compared to other flood management actions.

Category A: Flood infrastructure

Flood infrastructure management actions are the most capital intensive, in terms of both initial cost and annual costs. Costs are generally driven by construction, real estate, permitting, and mitigation expenses. Flood infrastructure also requires significant O&M funding.

Category B: Reservoir and Floodplain Storage and Operation

Reservoir and floodplain storage cost are initially high, depending on location and size of storage, real estate acquisitions, relocations, permitting/mitigation costs, and the complexity of facilities involved. In addition, small increases in annual O&M costs might be required. Floodplain storage is less expensive than reservoir storage, but costs vary based on location and construction. Costs for storage operations are lower than constructing additional reservoir or floodplain storage. Reservoir operations costs are initially low to medium and depend on location, facilities, forecasting, and hydrologic technology used. Annual costs for reservoir operations are variable.

PLACEHOLDER Table 28-1 Benefits and Costs of Management Actions

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of this chapter.]

Category C: Operation and Maintenance

Annual costs consist primarily of operations and maintenance of flood infrastructure facilities. These long-term annual costs typically were not considered when designing, constructing, and financing past flood infrastructure projects. Increased regulations and permitting requirements over the past several decades have further increased annual maintenance costs. Since all infrastructure has a defined service life, aging infrastructure eventually needs to be replaced, rehabilitated, or improved.

Category D: Land Use Planning

Land use planning actions are generally less costly than structural approaches. Land use planning typically involves relatively low funding for planning and adoption, with fewer long-term costs. Land use planning that reduces the amount of development in the floodplain keeps flood risk low and foregoes the need for expensive structural solutions and associated O&M costs.

Category E: Floodplain Management

The cost of floodplain management actions are higher for built environments than for native environments. Risk assessments and mapping fall within the moderate cost range. Land acquisitions and easements can require high initial costs, especially for floodplain lands that have already been developed. Retreat typically have initially high costs, but costs can vary widely based on the level of existing development and type of retreat required (relocation, abandonment, or demolition). Floodproofing structures within developed lands require significant initial costs, depending on the number of structures. The cost of flood insurance is determined by the NFIP and depends on the amount of insurance, date, and type of construction of the structure covered, and level of flood risk. Flood risk awareness, information, and education have low initial costs but require annual expenditures for program maintenance.

Category F: Natural Floodplain and Ecosystem Functions

Management Actins for natural floodplain and ecosystem functions are a good illustration of the need to balance short-term costs with long-term costs. Management Actions for ecosystem functions generally have medium to high initial costs, including real estate acquisitions, relocations, design, construction, permitting, mitigation, and potential loss of property taxes. In addition, annual costs initially increase during the establishment period for monitoring and adaptive management and can potentially increase some maintenance costs to accommodate improvements in habitat. However, long-term annual costs generally decrease because there is minimal or no infrastructure to maintain and replace.

Category G: Permitting

Regional and programmatic permitting is another good illustration of the need to balance short-term and long-term costs. Regional and programmatic permitting requires increased initial costs for development of habitat conservation plans or natural community conservation plans. However, programmatic permitting results in improved overall efficiency when compared to typical project-by-project permitting timelines. Bundling the projects reduces overall permitting costs.

Category H: Flood Management (Preparedness, Response, and Recovery)

Flood preparedness, response, and recovery management actions have relatively low initial costs that require some long-term funding to ensure that the programs, equipment, and personnel training remain effective. Costs for emergency response and post-flood recovery are difficult to predict and vary widely based on the intensity of the specific event. These costs are predominantly borne by county agencies, but regional, State, and Federal agencies provide additional support when needed.

Category I: Policy and Regulations

Policy and regulations that improve agency coordination and clarify flood management roles and responsibilities have low initial costs because they do not involve any physical construction. However, they provide the opportunity to decrease annual expenditures through streamlining and improving regional coordination. In addition, agency cost-sharing agreements can spread costs among agencies.

Category J: Finance and Revenue

The costs to implement changes in methods of finance and revenue accounting require low to moderate investment. These changes can include cost-sharing agreements, new sources of grant funding, loans, bonds, user fees, and other assessments. When implemented, such methods have the opportunity to reduce annual costs and reallocate costs across multiple agencies or benefactors. Initial costs could be slightly increased to implement agreements, fund referendums on bonds or assessments, or apply for grants or loans.

Major Issues Facing Flood Management

Major issues facing flood management were identified in the *California's Flood Future Report*. The identified issues were based upon interviews with more than 140 local, State, and Federal agencies, and tribal entities, with varying levels of flood management responsibilities in each county of the state. The agencies were asked about the status of flood management in their respective areas of responsibility. The following seven basic categories were identified as a result of this information gathering exercise and represent the primary issues to implementing an IWM approach to flood management:

- Issue 1: Risk Assessments
- Issue 2: Flood Risk Awareness
- Issue 3: Flood Readiness
- Issue 4: Land Use Planning
- Issue 5: Regional and System/Statewide Planning
- Issue 6: Agency Alignment
- Issue 7: Reliable Funding and Investment Prioritization

Issue 1: Risk Assessments

There is no consistent methods used for flood risk assessments, floodplain mapping requires updating, and accepted levels of protection have not been identified statewide. In California, only 23 risk assessments using the USACE risk methodology have been completed in the last 10 years. The CVFPP and other Central Valley efforts have provided the most comprehensive risk assessment of any region in the state. In addition, Santa Clara, Marin, Monterey, Ventura, Orange, Los Angeles, and San Luis Obispo counties have developed guidelines or approaches for project planning that consider components needed for a full risk assessment as defined by USACE. Currently, a number of methods are used to assess flood risk, which results in inconsistency across the state. The methods include those used by USACE, FEMA, and local agencies. These methods were each developed to reach unique objectives that required different levels of complexity. For example, FEMA uses an approach that has traditionally focused on the hazards associated with the 100-year and 500-year flood events, in contrast to USACE's approach that assesses and describes risk in terms of expected annual damage (EAD). A consistent method of assessing risk could be undertaken that would lead to a better understanding of flood risk, as well as more effective use of limited funding for flood management.

Data and mapping assistance is needed in large areas of the state to improve understanding of floodplains and the impacts of climate change. Identifying flood threats is an important first step toward reducing risk and prioritizing flood management needs in California. However, inadequate and outdated hydrologic and mapping data effectively make a barrier for performing risk assessments across the state. Funding is inadequate to meet current data and mapping needs in California.

Acceptable levels of protection have not been identified for all regions of the state; however, SB 5 established a 200-year requirement for the urban level of protection in the Central Valley. Due to the differences in climate, number of lives and value of property at risk, degree of urbanization, number of critical facilities, type of flood, and level of acceptable risk for the region, a one-size-fits-all approach is probably not workable in the state. Local agencies have to determine the acceptable level of protection is for their respective regions.

Issue 2: Flood Risk Awareness

Currently, many California residents and policy makers are primarily aware of exposure to flood hazards through the NFIP. This awareness might not include the risk of potential impacts that a flood event might have on critical facilities, neighborhoods, and the local economy or of the potential for damage from storms either larger than the 100-year event or occurring more frequently. A number of existing local, State, and Federal programs are focused on improving flood awareness, including FloodSmart, FloodSAFE, Risk MAP, plus other local, State, and Federal efforts. However, coordination and information-sharing between these efforts could be improved. In addition to understanding the consequence of flooding, the role and benefits of maintaining and restoring natural floodplains are not always understood by some residents and policy makers. Understanding the full cycle of flooding includes knowing that upstream alterations can have unintended impacts on downstream environments and flood risk. Flood inundation can support ecosystem functions and natural environments. Another issue that creates confusion in the public is that no common lexicon exists for local, State, and Federal flood management programs to describe flood risk to residents who have no engineering or risk management background.

Issue 3: Flood Readiness (Emergency Preparedness, Response, and Recovery)

In California, flood emergency preparedness, response, and recovery responsibilities are often fragmented among local, State, and Federal agencies within a region, and sometimes even within different departments of a single agency. These layers of responsibility are complicated by the hundreds of agencies that have differing governance structures. Each agency has its own governance structures that specify roles, responsibilities, and funding for the agency. Another issue facing local agencies is that funds for emergency planning are often the first funds cut during difficult or contracting budget cycles. These funding constraints make developing flood emergency plans and conducting preparedness activities difficult.

Issue 4: Land Use Planning

There needs to be a balance in land use planning among (1) economic need, including support for development, (2) public safety (i.e., managing risk by limiting development in floodplains), (3) maintaining ecosystem function, and (4) conservation of agricultural lands. Currently, development proposals are done on a project-by-project basis and do not necessarily include analysis of the long-term effects on or needs for flood management on a watershed scale. Many natural floodplains and their beneficial functions have been lost to encroaching development, mining, agriculture and other activities. Too often, regional and land use decision makers realize consequences of flood risk, environmental

impacts, public safety implications, and economic losses only after a damaging flood event. Local and regional planning agencies must ensure the planning process includes significant and real coordination, cooperation, and collaboration among planners, flood managers, resource managers, and emergency response managers. It is necessary to identify and plan for flood management and improve public safety by minimizing the acreage of floodplains lost to developments, along with reducing the number of Californians put at risk in floodplains. Local agencies do not have adequate resources to update and revise general plans yet have statutory deadlines to do so.

Another land use planning concern is the potential impact on public safety from future climate change. One area of deficiency in land use planning is developing strategies for retreat from areas subject to inundation due to climate change and sea level rise. The anticipated changes in climate are projected to have a significant impact on the timing and magnitude of precipitation and runoff, which increases flood risks. Rising sea levels combined with larger storms would increase flood risks in low-lying coastal areas and the Delta. Warmer temperatures and changes in soil moisture are expected to contribute to more frequent and intense wildfires. Areas damaged by these wildfires would have a greater potential for flooding associated with accelerated runoff. These changes could increase the number and severity of events in existing floodplains, and could expand floodplains.

Issue 5: Regional, Systemwide, and Statewide Planning

Traditional flood management projects primarily were developed to address a single-purpose problem. Today, due to water demands, environmental stressors, and the complex environment of regulatory, permitting, and water management agencies, this approach is no longer effective. The water system in California must balance flood management, water supply, environmental sustainability, and other regional goals. Therefore, it is important for flood management agencies, along with other water agencies, to work together on a regional basis to develop IWM approaches. In existing IWM efforts, flood components of projects have made up only a small percentage of the projects developed. Traditionally, flood management agencies have not been immersed in the California IWM process and generally have not worked together on regional solutions. Traditional flood planning efforts often did not include a diverse group of stakeholders. Regional, systemwide, and statewide planning efforts are typically more costly and time consuming, and these plans are difficult to implement due to the competing interests of stakeholders.

Issue 6: Agency Alignment

The complex governance structure in California makes agency coordination and alignment fragmented and difficult. Agency coordination issues include intra-agency, inter-agency, and coordination with regulatory and resource agencies. Fragmented flood management hampers proper flood and land use planning, limits funding for O&M and capital activities, and results in difficult and time-intensive permitting processes. Improper agency alignment results in projects that are single-issue focused, in missed opportunities for integration and funding maximization, and in projects that have unintended negative impacts on downstream or upstream communities and natural environments. For example, improper internal agency alignment can miss the opportunity to provide for adequate easements along rivers, creeks, and channels in areas where land is converting from one use to another, which could reduce the cost of flood management.

Issue 7: Reliable Funding and Investment Priorities

Current funding for flood management is inadequate and unreliable to provide flood management projects and ongoing O&M. Funding for projects is based on a bottom up approach where local agencies identify projects based on specific needs. State and Federal funding is allocated based on a set of guidelines that do not prioritizing projects statewide. Current funding for flood management in California is inadequate and unreliable because it is dependent upon agency user fees, assessments, bond funding, and earmarking. At current levels, funding needed to meet proposed near-term and long-term projects in California would take more than 100 years. This funding would not provide even a basic (100-year) level of protection across the state. In Orange County alone, it is estimated that $2 billion of flood improvements are needed to provide 100-year flood protection countywide; these improvements are not included in the near-term statewide improvement estimates. The county estimates that it will take 90 years to complete these investments at current funding levels.

Flood management program funding has been cyclical—often increasing following a flood disaster, then gradually decreasing as other priorities garner the attention of residents and policy makers. Funding is linked to county revenue and is impacted by changes in the state economy. Funding of flood management for local agencies is hampered by Propositions 13 and 218, which restrict an agency's ability to increase property assessments. Funding from assessments or impact fees can have limitations on where the funds can be spent geographically. For example, upstream infrastructure that decreases downstream risk could not be funded in a flood management assessment district because the infrastructure is not within the district's geographic boundary. Flood management budgets are especially susceptible to reductions in dry years or economic downturns.

Generally, flood management budgets have not fully addressed full life-cycle O&M needs, planning, and environmental impacts. O&M for projects is falling behind because of changes in regulatory requirements and increased permitting costs. Also, the cost of land use decisions that increase flood risk are often not included in agency budgeting.

Recommendations to Facilitate Flood Management

Planning and implementing flood management projects occurs on a fixed timeframe with a finite start and end, although the issues the planning projects are addressing often operate on a very different timeframe. This can present a unique set of challenges when developing a flood management project. Agency interaction that facilitates good communication, cooperation, and collaboration is needed for integrated solutions to flood management. Future flood management planning and actions should proceed, utilizing IWM as the overarching strategy. The objective is to implement a balanced planning framework that promotes multiple societal benefits, including public safety, environmental stewardship, and economic stability. This can be accomplished by agencies working together to:

- Conduct regional risk assessment to reduce flood risk.
- Increase awareness about flood risk to facilitate informed decisions.
- Support flood emergency management (preparedness, response, and recovery) programs to reduce risks to lives and property.
- Encourage land use planning practices that reduce risk to lives and property and protect existing ecosystems.

- Establish priority projects from a regional, systemwide, and statewide perspective to deliver multiple benefits.
- Facilitate and direct agency alignment, for improved governance and policy, to expedite priority projects.
- Establish multiple approaches to achieve reliable funding and develop statewide investment priorities.

These broad categories are used to organize recommendations. For the purposes of this document, including the recommendations, tribal entities are defined as federally recognized tribes and tribal communities.

Risk Assessments — Conduct Regional Flood Assessments to Reduce Flood Risk

1. **DWR, in coordination with local, State, and Federal agencies, should identify methodologies for assessing flood risk on a regional basis by 2015.** Because of the diversity of climate, geography, and types of flooding that exist across the state, a "one-size-fits-all" approach is not appropriate for identifying flood risks. Regional approaches that provide higher-level information can help target specific locations that require detailed studies.
2. **By 2017, DWR should provide technical assistance to local agencies for identifying goals for regional flood risk reduction and corresponding acceptable levels of residual risk.** Goals can be based on the number of lives and value of property at risk, critical facilities, depth and frequency of flooding, natural resources, land use (degree of urbanization), economic consequences, and level of acceptable risk for the region.
3. **By 2017, DWR should identify and develop methods for regional flood risk evaluation, and develop data requirements to establish project priorities**. The quality and quantity of flood risk data vary from agency to agency. No standard methodology is used to evaluate risk in California.
4. **Local, State, and Federal agencies should work together to develop the data and mapping required to perform regional risk assessments across the state by 2020.** These efforts will provide flood management agencies and local flood management agencies the data and tools they need to establish and achieve appropriate levels of flood protection. Goals should be based on the number of lives and value of property at risk, degree of urbanization, number of critical facilities, type of flood, and level of acceptable risk for the region.
5. **Local, State, and Federal agencies should work together to develop the data and mapping required to improve operation or flood management systems across the state by 2020.**
6. **DWR, University of California at Davis, USACE, USGS, and NOAA should develop a report on climate change and its impacts on flood hydrology which would focus on local extreme events instead of average precipitation and temperature changes by 2017**. This is important because flooding is impacted more by extreme events.
7. **DWR should create a catalog of information organized regionally, related flood risk including the impacts of climate change and sea level rise. Local, State, and Federal agencies should work together in the development of analytic tools that are tailored to the specific needs of local and regional flood planning by 2017.** Information about climate change and sea level rise has not been developed for all areas of the State; therefore, agencies need to work together to identify tools and to develop and catalog information for local and regional

areas. Tools should be tailored to the types of flooding and unique short timeframes (e.g. hours and days) and geographic scales (including small watersheds) used in local and regional planning. These tools should include information about strategies for retreat from areas that are subject to inundation resulting from climate change or sea level rise.

Flood Risk Awareness — Increase Awareness about Flood Risk to Facilitate Informed Decisions

1. **Local, State, and Federal agencies and tribal entities should work together to align and leverage existing awareness initiatives and to develop a common flood awareness lexicon by 2017.** Public education and information efforts should share a common language to describe flood risks and recommended actions in meaningful and measurable ways.
2. **By 2017, DWR should catalog, provide, and promote information resources about flood risk, floodplain awareness, and other related topics.** DWR should develop a comprehensive statewide database on flood management and make it accessible to flood management agencies, and tribal entities. The database should include natural floodplain resources, land use and watershed boundaries, and updated flood hazard areas. Simple access to data, case studies, budget information, and planning tools will improve local agency capabilities to identify opportunities for collaboration and integration. Additional online information resources should lead to an increase in overall flood risk awareness.
3. **By 2017, DWR should develop an online resource library of local, State, and Federal awareness program tools, templates, and other resource materials.** Shared resources save time and money and will facilitate public awareness efforts in regions where such efforts previously did not exist. Sharing resources will also help foster consistency among awareness programs. The online resource library should include, where available, floodplain mapping, risk maps, flood awareness information, hydrologic, geomorphic, and climate change data and information, relevant ecosystem information, and other relevant information. To develop this online resource library, Recommendations 29 and 30 will need to be completed.

Flood Readiness — Support Flood Emergency Management (Preparedness, Response, and Recovery) Programs to Reduce Risks to Lives and Property

1. **By 2017, DWR, working with CalEMA and other State agencies, should provide grant funding for increased coordination among flood responders, facility managers, planners, tribal entities, and representatives of State and Federal resource agencies to improve flood emergency management.** Coordination before a flood event improves emergency preparedness by identifying and reinforcing areas of expertise, available resources, and agreement about incident plans.
2. **State and Federal agencies working together should assist in the development or improvement of local flood emergency management plans by 2017.** This assistance should take the form of technical expertise, development of templates, and review of existing plans for consistency.
3. **By 2017, local, State, and Federal agencies should develop a plan to conduct annual floodfight training, and flood emergency preparedness and response exercises statewide.** Tabletop drills, participation in training and functional exercises are a necessary part of disaster preparedness.

4. **By 2017, local, State, and Federal agencies should identify a list of data and forecasting needs, including cost estimates for emergency management.** Accurate and timely forecasts for flood events can increase warning time, save lives, and reduce property damage. Additional data will help improve the readiness and response to floods. Providing data and tools to improve system reoperation will improve management of natural and manmade flood systems.

Land Use Planning — Encourage Land Use Planning Practices That Reduce Risk to Lives and Property and Protect Existing Ecosystems

1. **DWR should develop land use planning principles that will help local decision makers to account for risk for flooding, working with organizations such as the County Engineers Association of California (CEAC), Floodplain Management Association (FMA), Association of State Floodplain Managers (ASFPM), and American Planning Association (APA) by 2017.** Secure endorsements by these groups for the principles, and promote them as "industry best practices." These best practices should include definition of the "no adverse impact" philosophy for project planning.
2. **By 2020, DWR should link funding for flood management improvements to implementation of best management practices, including the preservation of existing floodplains and the restoration of natural floodplain functions, where feasible.** Fiscal incentives can help improve local land use planning to reduce risk to people and property, where feasible. Local flood management jurisdictions should promote the preservation of existing floodplains, the restoration of natural floodplain functions, and the careful analysis of the interface between natural or naturalized floodplains and structural flood management systems to ensure that erosion and debris deposition from these natural areas do not create undue hazards to downstream facilities and property. This would utilize land use practices indentified in Recommendation 27.
3. **By 2017, DWR should develop a plan and facilitate regular coordination at all levels among land use planners, resource managers, floodplain managers, and emergency response managers by holding annual regional meetings.** Coordination among planners, floodplain managers, resource managers, and emergency response managers can help to reduce impacts of flooding and improve public safety.
4. **By 2017, DWR should develop a plan and facilitate regular coordination, communication, collaboration, and consultation early in the flood management planning process with tribal entities.**
5. **DWR should create a report by 2015 that reviews the effectiveness of the 2007 flood legislation to determine whether it achieves what it was intended to achieve and recommend any refinements or improvements.**
6. **By 2017, legislation should be developed that prohibits local land use agencies from permitting new critical public facilities (such as fire stations, emergency shelters, hospitals, or schools) be constructed within the floodplain equivalent to the level of protection standard set by the region.** If no level of protection has been set then the floodplain used should be the 200-year floodplain. Existing critical facilities located in flood-prone areas should be noted in the Emergency Plans prepared by local agencies, with evacuation and egress routes clearly identified.
7. **By 2017, the Legislature should enact a statute that clarifies the definition of "reasonable" impacts on downstream drainage and property.**

Regional, Systemwide, and Statewide Planning — Establish Priority Projects from a Regional, Systemwide, and Statewide Perspective to Deliver Multiple Benefits

1. **By 2017, State and Federal agencies should provide incentives for system-scale flood management planning that encompasses conservation and restoration, including riverine, floodplains, and other ecosystem functions.** Performing planning at a watershed scale for flood management enables a more holistic approach to water and ecosystem management.
2. **By 2017, State and Federal agencies should provide incentives for tribal entities to perform system-scale flood management planning that encompasses conservation and restoration, including riverine, floodplains, and other ecosystem functions.** Performing planning at a watershed scale for flood management enables a more holistic approach to water and ecosystem management.
3. **Local, State and Federal agencies should identify regional flood planning areas by 2015.** Flood management planning areas throughout the state should be established with boundaries that are systemwide, watershed based where feasible, and consistent with existing Federal and State agency boundaries, including existing Integrated Regional Water Management (IRWM) Plan funding areas and existing CWP hydrologic regions. These areas would enable the complex array of flood management agencies to begin working together to resolve common issues on a regional basis. Ultimately, these planning areas could be coalesced with IRWM groups in a single planning entity.
4. **State flood management planning regions, once formed, should use the methodology developed for prioritizing flood management investments to establish regional priorities by 2020.** Regional flood management priorities, including a list of flood management projects, some with multiple objectives, can foster IWM actions.
5. **DWR should review existing programs, including IRWM guidelines and practices, to identify areas where improved coordination between water management and flood management agencies can be realized by 2017. This review should ensure that equal importance is placed on public safety, environmental stewardship, and water management.** Review and make recommendations about existing State programs to identify changes that can be implemented to improve coordination between flood management and IWM programs.
6. **DWR should ensure that guidelines, tools, and technical assistance for IWM include flood management best practices by 2017. DWR should provide technical assistance to local flood management agencies that encourage an IWM approach**. Improved guidelines and technical assistance will provide tools and incentives for local implementation.
7. **DWR should update the Statewide Flood Management Planning *California's Flood Future Report* by 2017 and every 5 years thereafter.** The update should include updated risk assessment information; and address regional planning efforts (including prioritized projects), flood readiness, flood awareness initiatives, land use decision-making and agency alignment efforts in the context of IWM, flood-related funding needs; and include an update to the recommendations to improve flood management.
8. **[Add CVFPP Recommendation]**
9. **DWR should continue incentives and support for the maintenance of IRWM plans that address regional flood management issues.**

10. **By 2017, resource agencies should give priority to permitting projects with a public safety purpose.** Prioritizing public safety projects, including flood management, will protect lives, property, and sensitive habitats.

Agency Alignment — Facilitate and Direct Agency Alignment, for Improved Governance and Policy, to Expedite Priority Projects

1. **Local, State and Federal agencies and tribal entities should establish regional working groups to achieve programmatic and site-specific permitting for planning and implementation of flood projects by 2017.** Local, State, and Federal agencies and tribal entities should work together to develop solutions and resolve regional issues, including permitting of new and existing facilities or projects. These agencies could work together to incentivize participation by resource agencies regional working groups that focus on flood project planning and implementation, and that address all relevant regional IWM issues. These working groups would provide a forum to facilitate discussions about permitting and regional issues. The working groups could also focus on developing regional recommendations for improving the environmental review and permitting process for routine O&M of structural facilities.
2. **State and Federal agencies should realign existing internal processes to support regional groups that undertake regional flood planning by 2020.** State and Federal agencies can assist local agencies in removing barriers to expediting project delivery and promoting multiple benefits projects by modifying internal agency processes and programs. This effort should include the development of common terminology for State and Federal programs, which would help agencies understand the varying aspects and benefits of multiple objective projects.
3. **Resource agencies should collaborate to develop a permitting guidebook that include a description of the relevant permits, permit applications, and permitting guidance by 2017.** The guidance would include: what type of permits required for flood management projects and guidelines for when permit is needed, what permitting agencies require to issue these permits and how and when to coordinate with regulatory agencies for project-specific and regional permitting approaches.

Reliable Funding and Investment Prioritization — Establish Multiple Approaches to Achieve Reliable Funding and Develop Statewide Investment Priorities

1. **State and federal agencies should collaborate and promote more consistent application requirements when applying for State and Federal funding programs that fund flood management projects.** A universal base application form could be created and used for all funding programs, and supplementary forms could be tailored to specific funding programs to reduce redundancies.
2. **DWR, along with other State and Federal agencies should examine and realign guidelines to existing programs, including grants to incentivize projects that deliver regional, systemwide, and statewide benefits by 2017.** This will encourage local agencies to align for faster project delivery and multiple benefit projects. Programs such as the DWR subventions funding program, FEMA and NRCS grant funding, and other programs could be realigned to weigh funding toward multiple -benefit or watershed-based projects.
3. **State and Federal agencies should develop a central online resource catalog of flood management funding sources by 2017.** This should include development of a database that de-

scribes the different funding programs, and how local agencies should apply for funding. The database should be made available to interested parties.

4. **Local, State and Federal agencies should work together to develop a roundtable to assess the viability of all potential funding sources, propose new funding options, and identify needed changes to legislation by 2020.** Roundtable would initially review existing funding sources identified in the online resource catalog created in Recommendation 4, review other funding mechanisms, and make recommendations. The roundtable also should propose changes or alterations to local funding restrictions by pursuing exemptions to existing statutes for public safety. For example, changes to Proposition 218 legislation could include reclassification of flood management agencies as exempted public safety utilities. The roundtable could also pursue the establishment of regional assessment districts.
5. **DWR, in cooperation with local agencies, would create a task force by 2015 to evaluate whether forming regional maintenance authorities would increase economies of scale and increase funding for performing operations and maintenance responsibilities.**
6. **The State should establish a consistent methodology for evaluating qualitative benefits, such as ecosystem restoration, recreation and open space, water supply, groundwater recharge, sustainability, and community/social benefits. The State would also establish a consistent methodology for evaluating systemwide benefits by 2015.**
7. **Local, State, and Federal agencies should work together to develop a methodology for prioritizing funding statewide and use the methodology for flood management investments by 2017.** Agencies should work together to identify acceptable regional levels of protection, develop needed data and mapping, complete risk assessments, and prioritize projects statewide. The prioritization should be based on the magnitude of flood risks that would be avoided and the number of benefits that would be provided, including the magnitude of ecosystem and water resources benefits that would be created.
8. **State and Federal agencies should work together to incentivize and provide technical assistance to tribal entities for development of flood management and emergency management plans by 2017.**

References

References Cited

California Department of Water Resources (DWR). *California's Flood Future: Recommendations for Managing the State's Flood Risk*. Prepared by CH2M HILL. 2012.

Federal Emergency Management Agency (FEMA). 2010. *Floodplain Management Requirements, A Study Guide and Desk Reference for Local Officials, Unit 1: Floodplain Management*. Available at: http://www.fema.gov/plan/prevent/floodplain/fm_sg.shtm. August 11. Accessed July 12, 2012.

Federal Emergency Management Agency (FEMA). 2012. National Flood Insurance Program, Definitions. Available at: http://www.fema.gov/business/nfip/19def2.shtm. Accessed July 6, 2012.

Kelley, Robert. 1989. *Battling the Inland Sea*.

Additional References

Personal Communications

Table 28-1 Benefits and Costs of Management Actions

Management Action Category	Management Action	Flood Risk Reduction Benefits	Other Benefits						Costs
			Water Supply	Ecosystem Restoration	Recreation	Water Quality	Hydropower	Navigation	
Category A: Flood Infrastructure	Levees and Floodwalls	Addresses all types of flooding by reducing the frequency of flooding. Reduces the susceptibility of people and property from harmful flooding. If development is encouraged behind levees, residual risk would increase.	X [a]	X [a]	X				High initial costs, depending on location, amount, real estate needs, permitting/mitigation costs. Additional annual O&M costs required.
Category A: Flood Infrastructure	Channels and Bypasses	Predominantly addresses slow-rise and flash flooding. Reduces the susceptibility of people and property from harmful flooding.	X	X	X			X	High initial costs, depending on location, amount, real estate needs, permitting/mitigation costs. Additional annual O&M costs required.
Category A: Flood Infrastructure	Coastal Armoring Structures and Shoreline Stabilization	Addresses coastal flooding by reducing the frequency of flooding and reducing erosion rate. Reduces the susceptibility of people and property from harmful flooding. If development is encouraged behind armoring structures and shoreline stabilization, residual risk would increase.		X [b]	X [b]				High initial costs, depending on location, amount, real estate needs, permitting/mitigation costs. Additional annual O&M costs required.
Category A: Flood Infrastructure	Debris Mitigation Structures	Addresses debris and alluvial fan flooding by retaining debris and reducing downstream flooding. Reduces the susceptibility of people and property from harmful flooding.				X			Medium-high initial costs. High annual O&M costs for debris removal and disposal.
Category B: Reservoir and Floodplain Storage and Operations	Reservoir and Floodplain Storage	Addresses slow-rise and flash flooding. Reduces the probability, extent, and depth of flooding. Reduces frequency of flooding and residual risk by reducing peak flows.	X	X	X		X		Medium to very high initial costs depending on location and size of storage, real estate acquisitions, relocations, permitting/mitigation costs, complexity of facilities. Additional small annual O&M costs.

Management Action Category	Management Action	Flood Risk Reduction Benefits	Other Benefits						Costs
			Water Supply	Ecosystem Restoration	Recreation	Water Quality	Hydropower	Navigation	
Category B: Reservoir and Floodplain Storage and Operations	Storage Operations	Addresses slow-rise and flash flooding by reducing frequency and magnitude of downstream flooding and reducing residual risk. Reduces the probability, extent, and depth of flooding. Coordinated operations can involve transfer of risk, increasing risk in one area, while decreasing risk in another.	X	X	X		X		Low-medium initial costs, depending on location, extent of facilities, forecasting and hydrologic technology used. Annual costs are variable.
Category C: Operations and Maintenance		Addresses all types of flooding. Reduces vulnerability of flood infrastructure. No change in residual risk.		X				X [c]	Low initial costs. Medium to high annual costs depending on type and extent of maintenance.
Category D: Land Use Planning		Addresses all types of flooding. Reduces risk by reducing who and what is flooded. No reduction in residual risk.	X	X	X	X			Low initial costs. No significant change to annual costs.
Category E: Floodplain Management	Floodplain Mapping and Risk Assessments	Addresses all types of flooding. Does not directly reduce flood risk, but reduces who and what might be flooded if it leads to land use decisions that are consistent with floodplain function. Reduces residual risk.							Low initial costs. Low to medium annual costs.
Category E: Floodplain Management	Land Acquisitions and Easements	Addresses all types of flooding. Reduces risk by reducing who and what is flooded. No redirected hydraulic impacts and reduction in residual risk.	X	X	X	X			High initial costs based on location, extent, or type of easement. Costs include real estate acquisitions, relocations, mitigation costs, engineering, and permitting costs. Annual costs vary.
Category E: Floodplain Management	Building Codes and Floodproofing	Addresses all types of flooding. Reduces who and what is flooded and the susceptibility of people and property from harmful flooding. Reduces residual risk.							Low initial costs for building code changes and costs for implementation could be recovered through additional fees. Medium to high initial costs for floodproofing depending on number of structures.

Management Action Category	Management Action	Flood Risk Reduction Benefits	Other Benefits						Costs
			Water Supply	Ecosystem Restoration	Recreation	Water Quality	Hydropower	Navigation	
Category E: Floodplain Management	Retreat	Addresses coastal flooding by reducing who and what is flooded and the susceptibility of people and property from harmful flooding. Reduces residual risk.		X	X				Medium to high initial costs depending on type of retreat, location, extent, type of structure, real estate acquisitions, mitigation, and permitting costs
Category E: Floodplain Management	Flood Insurance	Addresses all types of flooding. Reduces the susceptibility of people and property from harmful flooding. Reduces residual risk.							Low to medium initial costs. Low annual costs.
Category E: Floodplain Management	Flood Risk Awareness, Information, and Education	Addresses all types of flooding. Does not directly reduce flood risk, but reduces who and what might be flooded if it leads to land use decisions that are consistent with floodplain function. Reduces residual risk.							Low initial costs. Low to medium annual costs depending on extent of training and how flood information is disseminated.
Category F: Natural Floodplain and Ecosystem Functions	Encourage natural hydrologic, geomorphic, and ecological processes	Addresses all types of flooding. Can reduce peak flood flows and decrease the frequency, extent, and depth of flooding. No change in residual risk.	X	X	X	X			Medium to high initial costs based on size of project, real estate acquisitions, relocations, permitting, design, construction, mitigation, and loss of property taxes. Annual O&M costs could increase during establishment period but reduce annual costs over long-term.
Category F: Natural Floodplain and Ecosystem Functions	Improve the quantity, quality, and connectivity of native floodplain habitats	Does not directly reduce flood risk. Can provide mitigation opportunities for habitat losses elsewhere for flood management. No changes in residual risk.	X	X	X	X			Highly variable initial costs depending on type of effort, real estate acquisitions, relocations, permitting, design, construction, and potential loss of property taxes. Annual costs should increase short term, but decrease long term.

Management Action Category	Management Action	Flood Risk Reduction Benefits	Other Benefits						Costs
			Water Supply	Ecosystem Restoration	Recreation	Water Quality	Hydropower	Navigation	
Category F: Natural Floodplain and Ecosystem Functions	Reduce Incidence of Invasive Species	Addresses all types of flooding. Reduces the probability, extent, and depth of flooding by decreasing channel capacity and increasing rate of sedimentation.		X	X				Medium initial costs with potential costs related to permitting, maintenance, mapping, and technical evaluation on how to control invasive species. Annual maintenance costs would increase slightly.
Category G: Permitting	Regional and Programmatic Permitting	Addresses all types of flooding by reducing the cost and time for project delivery of flood management projects.	X	X	X	X			Medium to high initial costs to support plans such as Habitat Conservation Plans and Natural Community Conservation Plans. Decrease initial and annual costs of regulatory compliance and mitigation for O&M and repair activities.
Category H: Flood Emergency Management (Flood Preparedness, Response, and Recovery)	Flood Preparedness	Addresses all types of flooding. Reduces the susceptibility of people and property from harmful flooding. Reduces residual risk by reducing the consequences of flooding.							Low to medium initial costs. Low annual costs.
Category H: Flood Emergency Management (Flood Preparedness, Response, and Recovery)	Emergency Response and Floodfighting	Addresses all types of flooding. Reduces the susceptibility of people and property from harmful flooding. Reduces residual risk by reducing the consequences of flooding							Low to medium initial costs. Low annual costs.
Category H: Flood Emergency Management (Flood Preparedness, Response, and Recovery)	Post-Flood Recovery	Addresses all types of flooding. Does not directly reduce flood risk, but improves public safety in the aftermath of a disaster.							Low to medium initial costs. Low annual costs.

Management Action Category	Management Action	Flood Risk Reduction Benefits	Other Benefits						Costs
			Water Supply	Ecosystem Restoration	Recreation	Water Quality	Hydropower	Navigation	
Category I: Policy and Regulations		Addresses all types of flooding. Does not directly reduce flood risk, but improves coordination among agencies involved in flood management.							Low initial costs. Potential to decrease annual O&M costs through improving regional coordination.
Category J: Finance and Revenue		Addresses all types of flooding. Does not directly reduce flood risk, but improves ability to finance flood management projects.							Low to medium initial costs. Costs could decrease with integrated projects as opposed to multiple projects in isolation.

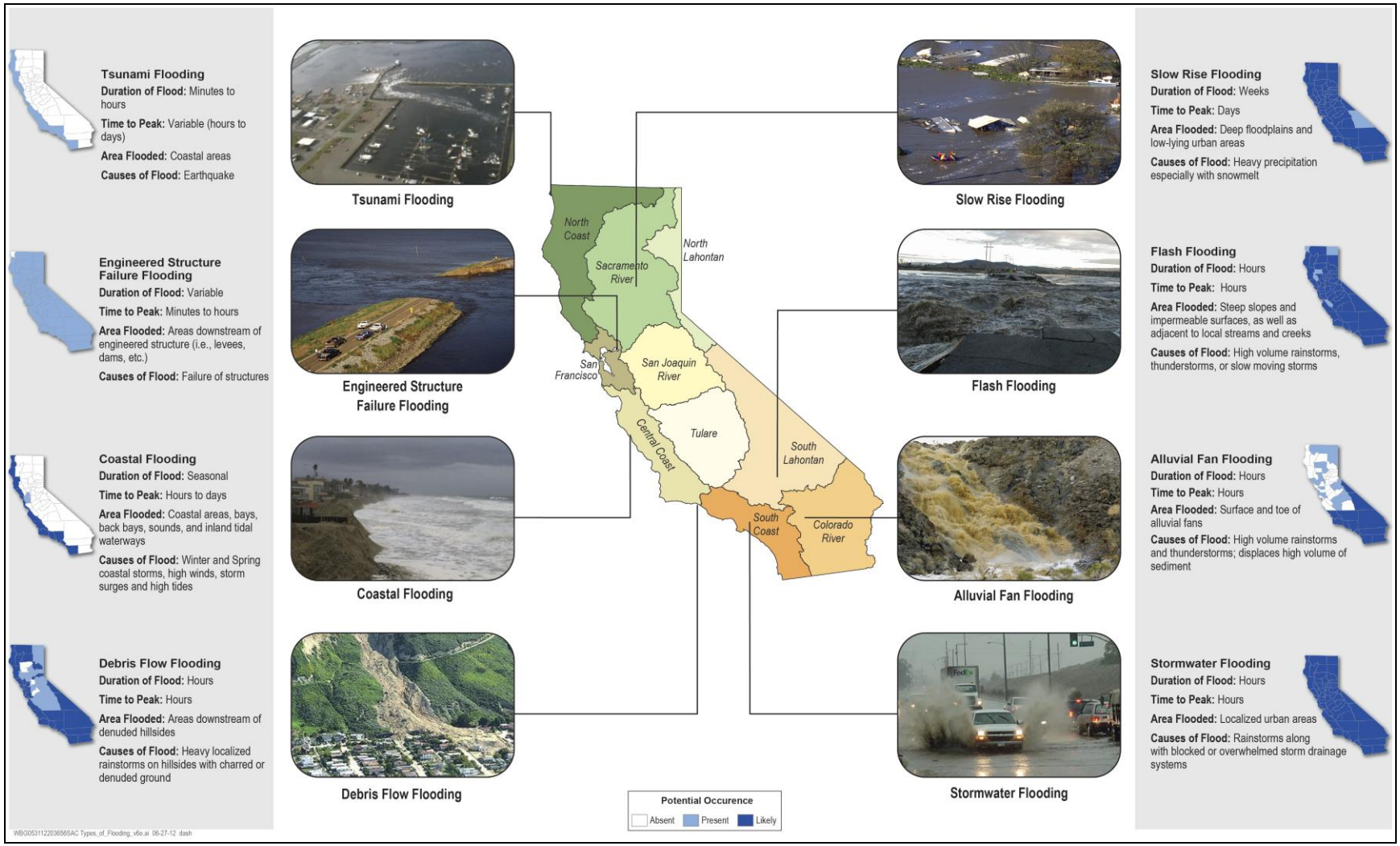
Notes:

[a] For setback levees only

[b] For natural and artificial reefs

[c] For dredging activities only

Figure 28-1 Flood Types in California



Box 28-1 Flooding Defined

A flood is defined as:

- A general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties from:
  - Overflow of inland or tidal waters; or
  - Unusual and rapid accumulation or runoff of surface waters from any source; or
  - Mudflow; or
- Collapse or subsidence of land along the shore of a lake or similar body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels that result in a flood as defined above.

— FEMA 2012

Box 28-2 Lower Carmel River Floodplain Restoration and Flood Control Project

The Lower Carmel River Floodplain Restoration and Flood Control Project provides an example of how flood management actions can be combined to address a variety of flooding issues in a single project. Human activities and infrastructure — water diversions, gravel mining, agricultural and urban development, roads, levees, bridges, and buildings — have altered the Lower Carmel River by isolating the floodplain from the river channel. Thus, the reduced floodplain acreage and has redirected flood flows, which caused repetitive flooding problems, resulting in significantly compromised riparian and wetland habitat, increased sedimentation at the river mouth, and increased erosion in adjacent scenic coastal roadways during flood events. The Big Sur Land Trust, Monterey County Water Resources Agency, Monterey County Public Works Department, and California Department of Parks and Recreation are planning and implementing a variety of management actions to address flooding on the Lower Carmel River, including:

- Modifying placement and/or size of existing levees and/or floodwalls, and adding new levees or floodwalls to improve flood protection.
- Improving hydrologic functions by reconnecting floodplains through regrading lands; modifying, setting back, or removing nonstructural levees; restoring channels and constructing bypasses; revegetating with native species; and reestablishing riparian and wetland habitat in the floodplain and off-channel wetland habitat.
- Integrating storage and filtration basins into restored floodplains to increase flood flow retention, promote sediment and nutrient removal, and increase groundwater recharge.

The total project cost is estimated to be approximately $18 million.

PLACEHOLDER Photo A Highway 1 Bridge over the Carmel River during the March 1995 Flood

[The draft photo follows the text of this box.]

Photo A Highway 1 Bridge over the Carmel River during the March 1995 Flood

Source: Monterey Peninsula Water Management District

Box 28-3 Upper San Diego River Improvement Project

The Upper San Diego River Project led by Lakeside's River Park Conservancy provides an example of how a flood management project can provide multiple benefits. The Lakeside community along the upper San Diego River has been dominated by sand mining since the 1930s. Two sand mining ponds have created deep, open water in the river channel, which traps sediment and decreases the capacity of the channel during a flood. Many of the natural functions of the river, including habitat, water quality, and recharge, have been lost in the process of channelizing portions of the river. In addition, the river has lost its place as a source of recreation in the community. The focus of the project was to fill the two existing ponds and restore the natural functions of the San Diego River Corridor on a 100-acre site formerly used as a sand and gravel mine. The total project cost was $20.5 million and achieved multiple benefits including:

- **Flood:** Widened and restored a channel to increase conveyance capacity, reduce flood levels, improve sediment balance, protect downstream bridges and water pipeline, and prevent urban development in a floodplain that is subject to development pressure.
- **Environmental:** Created, restored, and enhanced more than 90 acres of wetland habitat for threatened and endangered species, and improved downstream water quality with the creation of constructed wetlands and a bioswale.
- **Water supply:** A constructed wetlands treats urban runoff and allows it to recharge into the aquifer, increasing groundwater storage, which supports municipal wells important to the local community.
- **Recreation:** Added approximately 1 mile of publicly accessible new river trails along the banks of a newly restored river channel. The project includes camping areas, trails, and a boardwalk along the edge of the pond with access for the disabled and interpretive educational information.
- **Transportation:** In a beneficial collaboration with Caltrans, 400,000 cubic yards of fill material from channel excavation were used to construct the extension of State Route 52 to Highway 67, producing cost savings for both agencies.

PLACEHOLDER Photo A Riverford Washout 1980

[The draft photo follows the text of this box.]

Photo A Riverford Washout 1980

Source: Lakeside's River Conservation District. Photograph courtesy of Peter Nelson